$0\nu\beta\beta$ in effective field theory and simplified models

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With:
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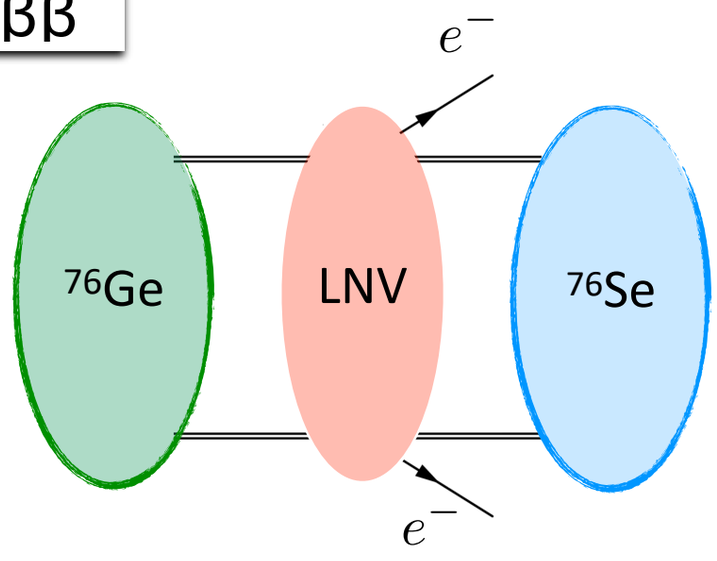
https://www.snowmass21.org/docs/files/summaries/RF/SNOWMASS21-RF4_RF0-NF3_NF2-TF11_TF0-051.pdf

Introduction

0νββ



- Very sensitive probe of lepton number violation
- Stringently constrained experimentally

$T^{0\nu}_{1/2}(^{76}\mathrm{Ge})$	$T^{0\nu}_{1/2}(^{130}\mathrm{Te})$	$T^{0\nu}_{1/2}(^{136}\mathrm{Xe})$
$> 9 \cdot 10^{25}\,\mathrm{yr}$	$> 3.2 \cdot 10^{25}\,\mathrm{yr}$	$> 1.1 \cdot 10^{26}\,\mathrm{yr}$

- To be improved by 1-2 orders

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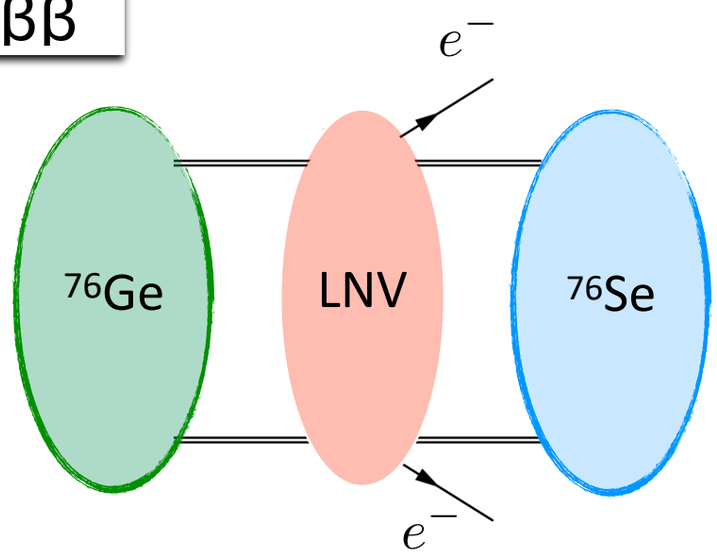

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Measurement would tell us:

- There's physics beyond the SM
- Neutrinos are Majorana particles

Have implications for

- Neutrino mass mechanism
- Leptogenesis

Schechter, Valle, `82

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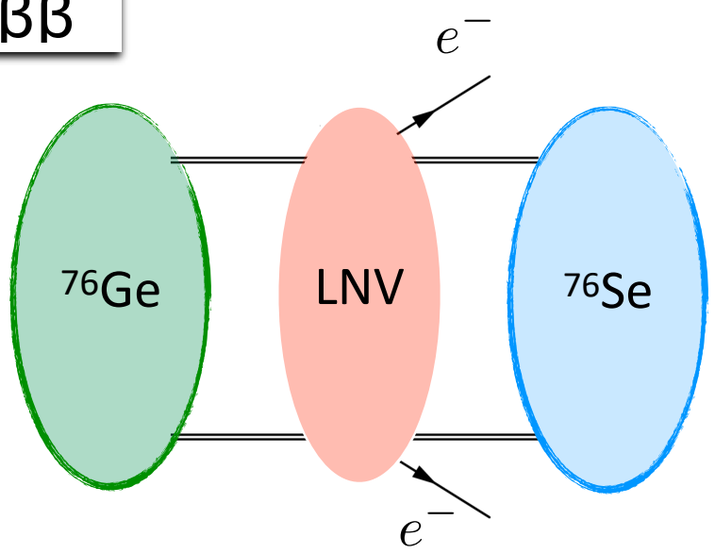

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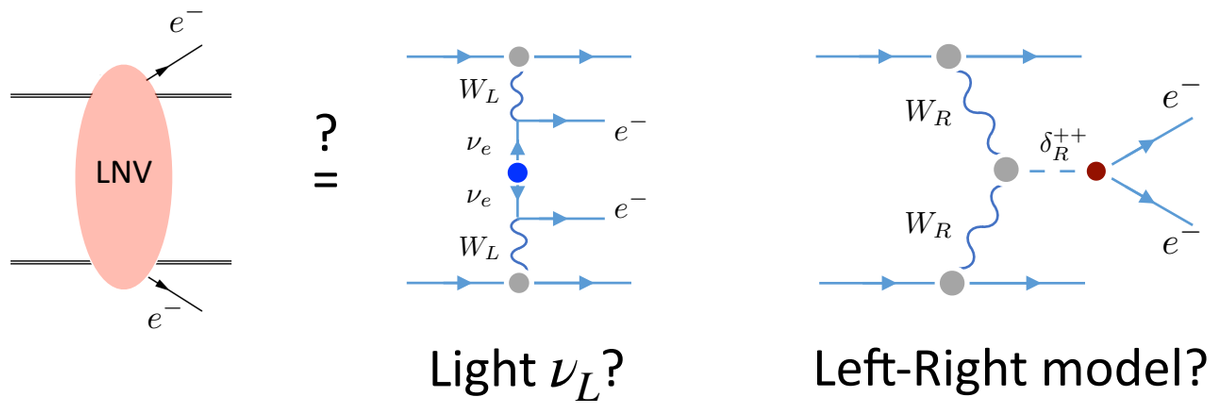
Not which LNV source is responsible

- Many possible mechanisms:



Light ν_L?

Left-Right model?

- Hard to disentangle using 0νββ alone

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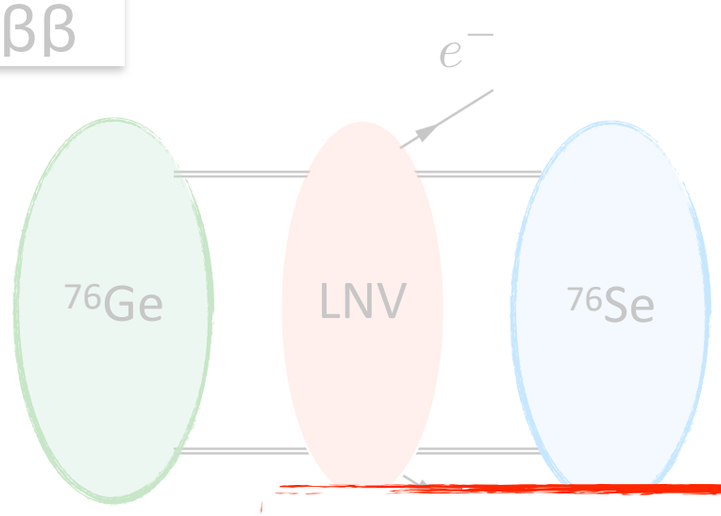
0νββ



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Complementarity between 0νββ and energy frontier is important

Collider probes could provide information on the LNV source

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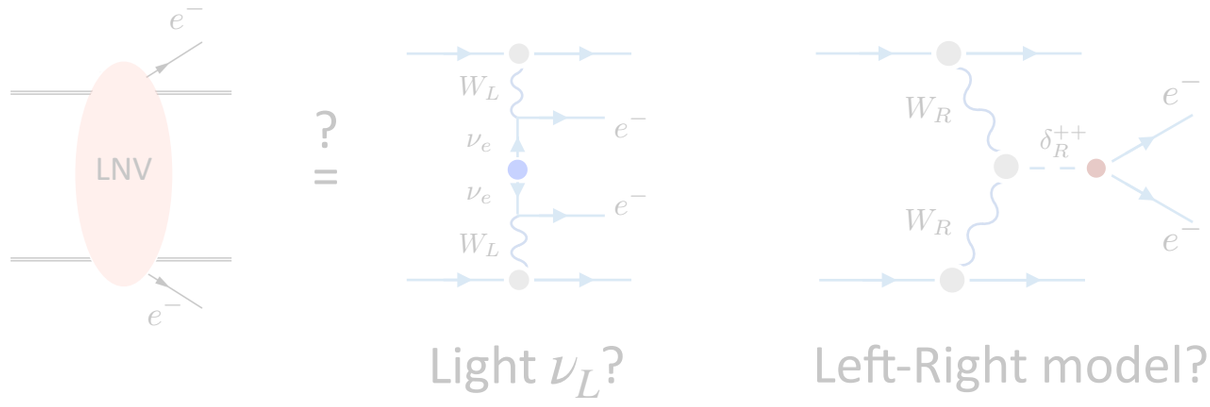

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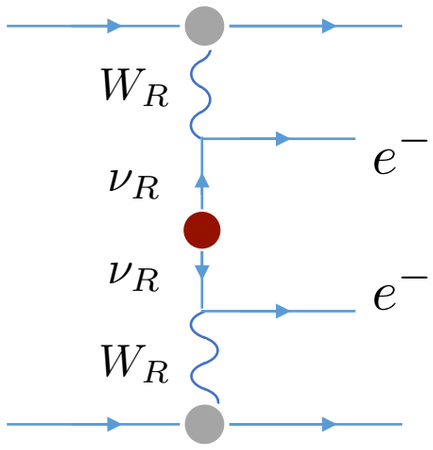
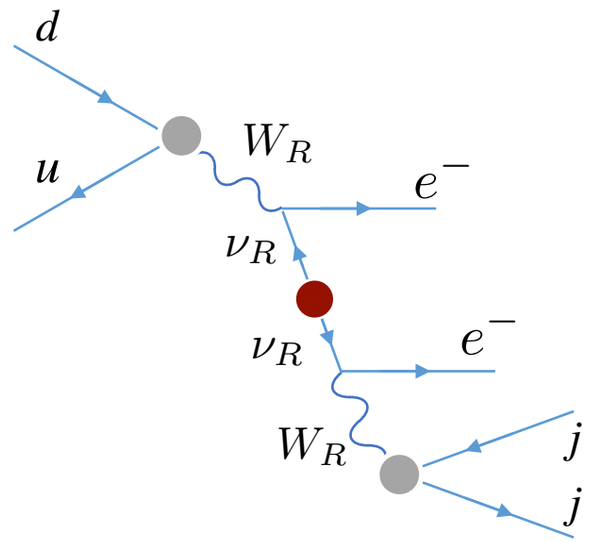
0νββ and collider interplay

- Many LNV models imply signals in 0νββ and at colliders
  - For example, in the Left-Right model:

0νββ



Collider



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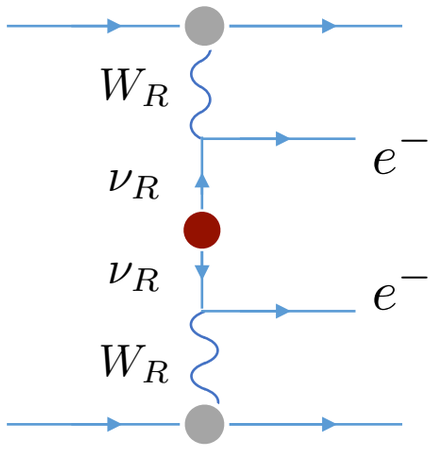
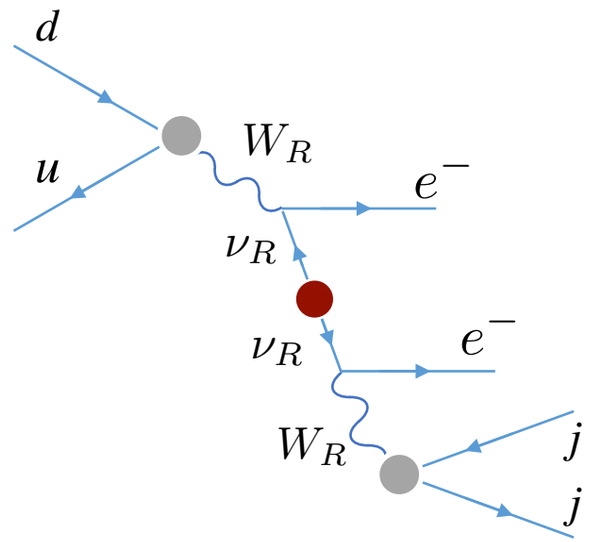


- Low-energy process
- Conveniently described using *EFTs*

Collider



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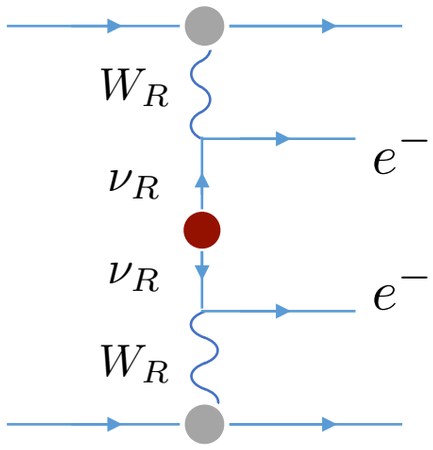

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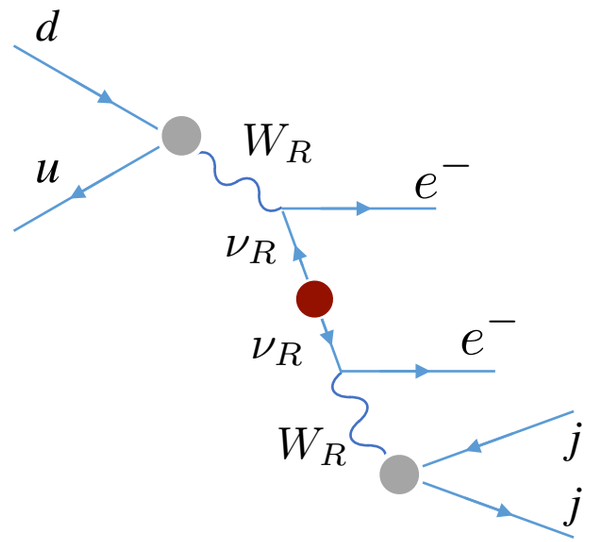

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  - Must keep new states $m_{\text{BSM}} \lesssim \sqrt{s}$
- Have to consider *specific BSM models*

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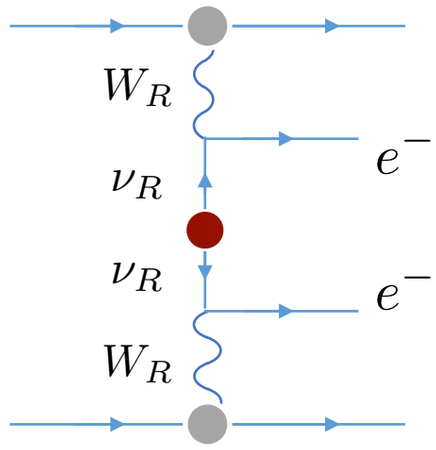

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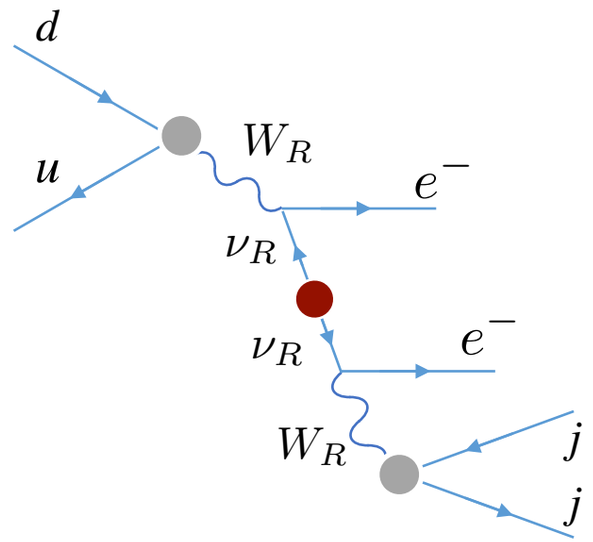

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- Goal: translate between the *EFT* and *model* description for several simplified scenarios
  - Assess the interplay 0νββ between and colliders

Proposal

- Consider several Simplified or Full models
  - Perform analysis of collider signatures within these models
  - Translate to the EFT and use it to describe $0\nu\beta\beta$

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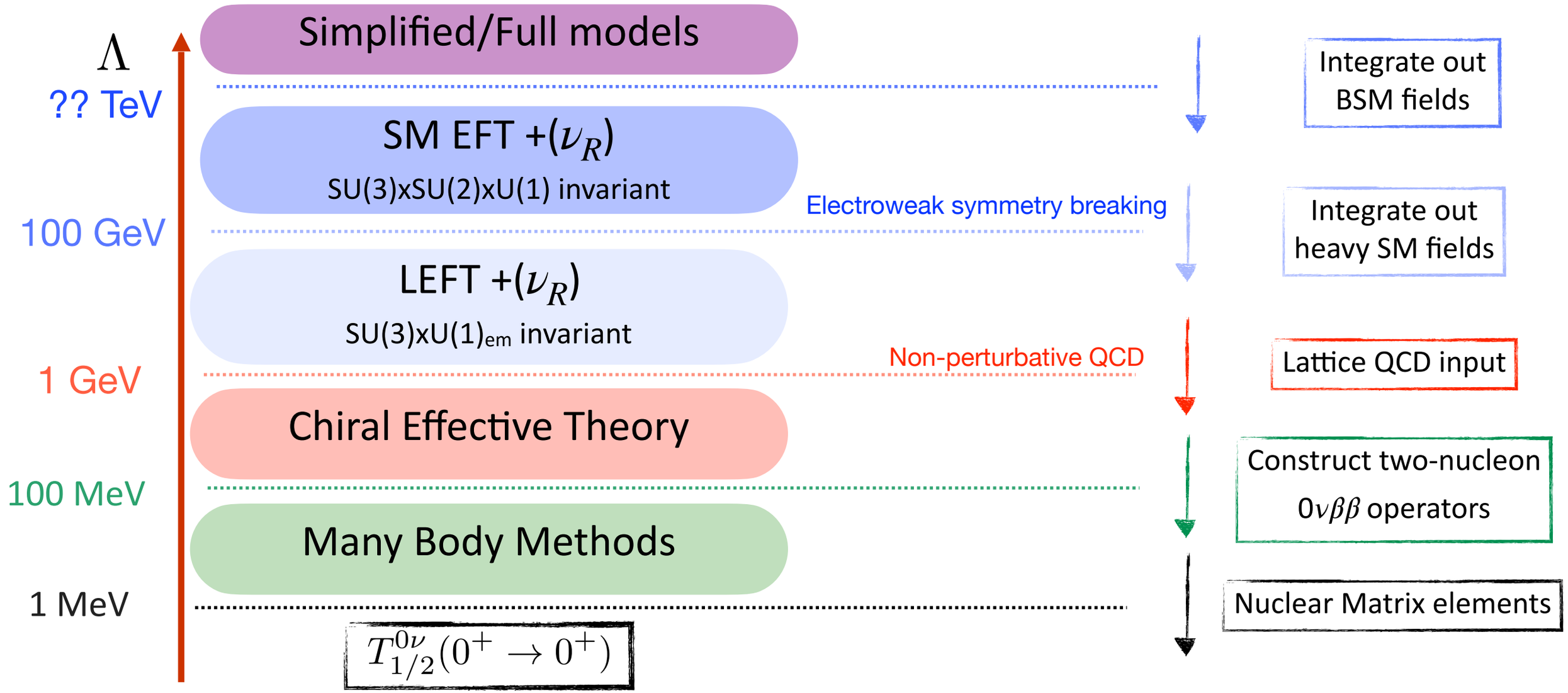
Framework developed in
V. Cirigliano et al, '17, '18, WD et al '20



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Λ
?? TeV

Simplified/Full models

Integrate out BSM fields

SM EFT +(ν_R)
SU(3)xSU(2)xU(1) invariant

Electroweak symmetry breaking

Integrate out heavy SM fields

100 GeV

LEFT +(ν_R)
$SU(3)xU(1)_{em}$ invariant

Non-perturbative QCD

Lattice QCD input

1 GeV

Chiral Effective Theory

Construct two-nucleon $0\nu\beta\beta$ operators

100 MeV

Many Body Methods

Nuclear Matrix elements

1 MeV

$T^{0\nu}_{1/2}(0^+ \to 0^+)$

- New step: matching of the simplified models onto the (ν)SMEFT

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- Models to be considered:

  - Phenomenological Type-I seesaw model
    - SM fields + two or more ν_R

  - Minimal Left-Right Symmetric model
    - Introduces right-handed neutrinos and gauge fields
    - SM fields + ν_R, W_R

  - Type I+II seesaw model
    - SM fields + ν_R + scalar $SU(2)_L$ triplet

  - Phenomenological Type I+III seesaw model
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- Suggestions for other scenarios that we should consider including are welcome!